Evaluation of Frictional Characteristics of Precision Machined Surfaces

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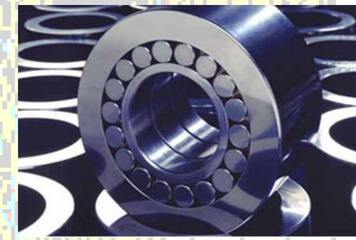
Presentation Outline

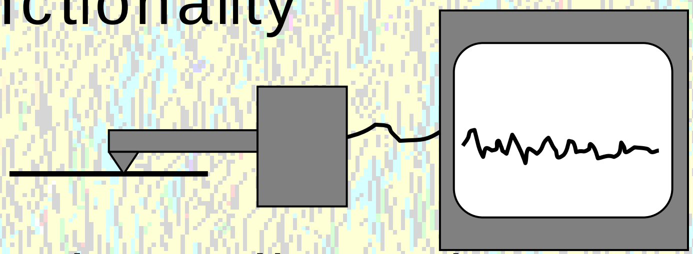
1. Introduction
2. Surface testing rig design
3. Rolling/sliding contact experiments
   - Experimental Design
   - Three-dimensional surface characterization
   - Results and discussion
4. Simulations

Introduction

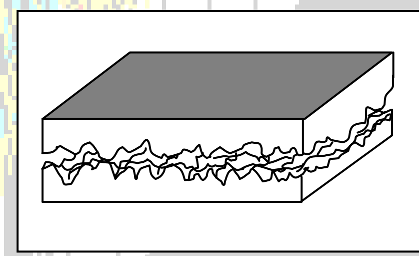
Problem Statement

- Experience shows advantages of certain finishes in certain roles
- 2-D roughness measurements (stylus) often correlated with functionality





- Surfaces contact in three dimensions
- Effect of specific 3-D texture parameters function not fully understood



- Coefficient of friction is of great importance to roller bearing type contact (rolling/sliding)

Introduction

Benefits of Solution

Gains against friction losses in rolling/sliding contact would lead to:

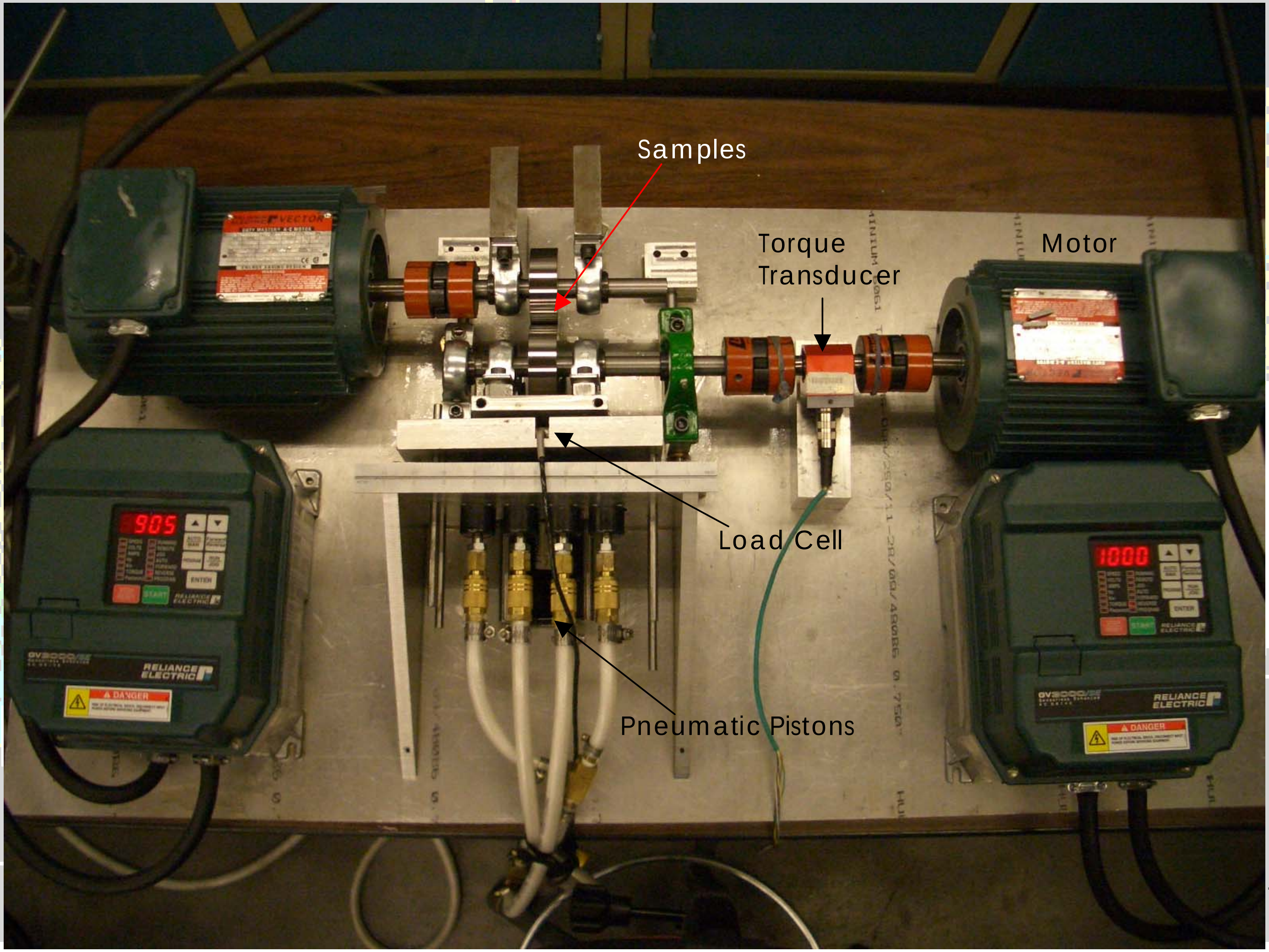
- Less heat produced resulting in lower cooling costs
- Smoother operation making power consumption more efficient and lowering loads
- Less wear leading to longer component life

Also, new finishing processes could be developed to more closely control vital surface parameters and optimize frictional response

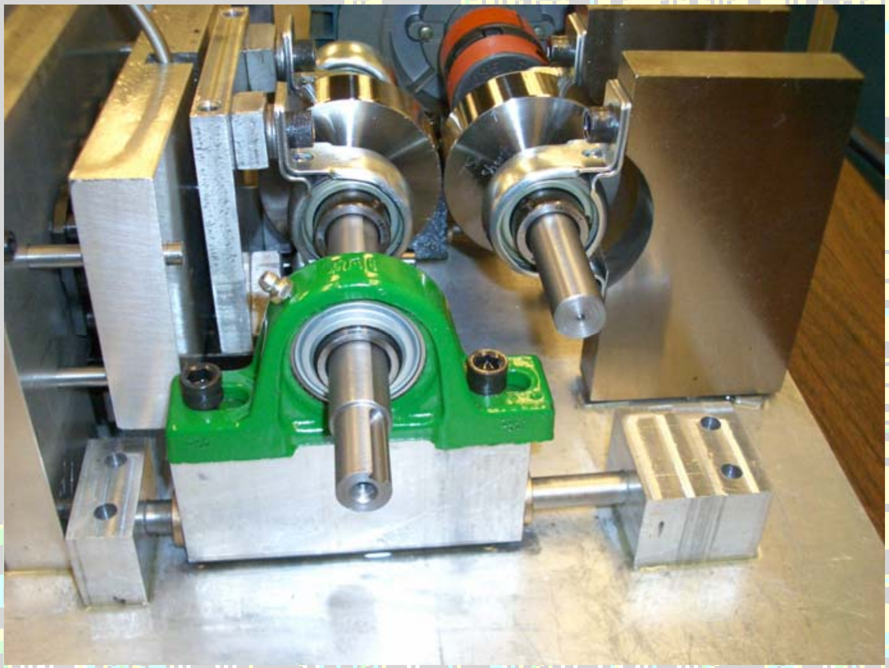
Research Objectives

- Design and construct a rolling/sliding friction testing apparatus
- Investigate effect of precision finished surface texture on coefficient of friction in rolling/sliding contact
- Correlate 3-D surface texture parameters with coefficient of friction

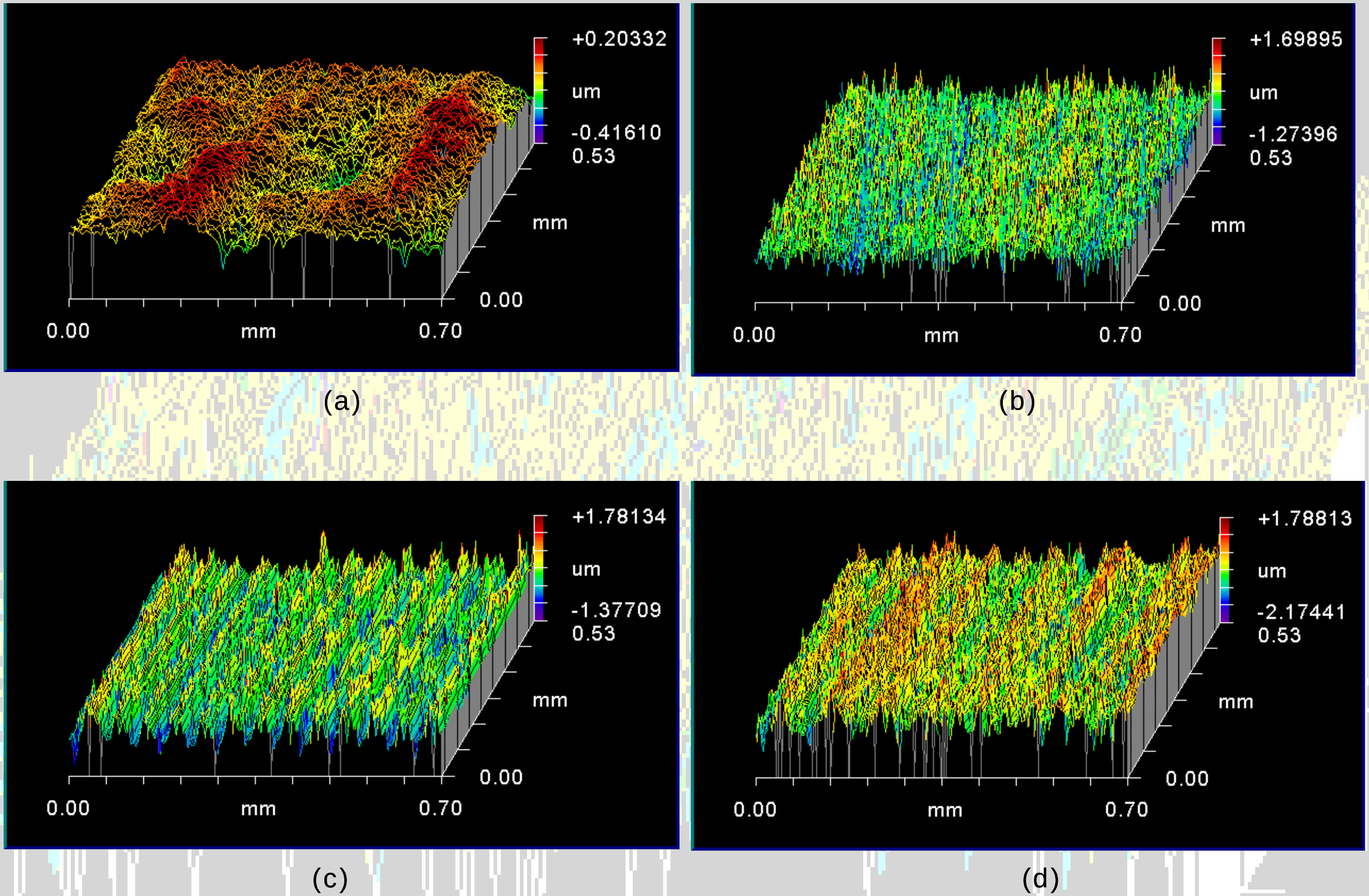
Surface Testing Rig Design



Surface Testing Rig Design



3-D Surface Characterization



Topographic Maps of (a) IF, (b) HN, (c) HT, and (d) GD

3-D Surface Characterization

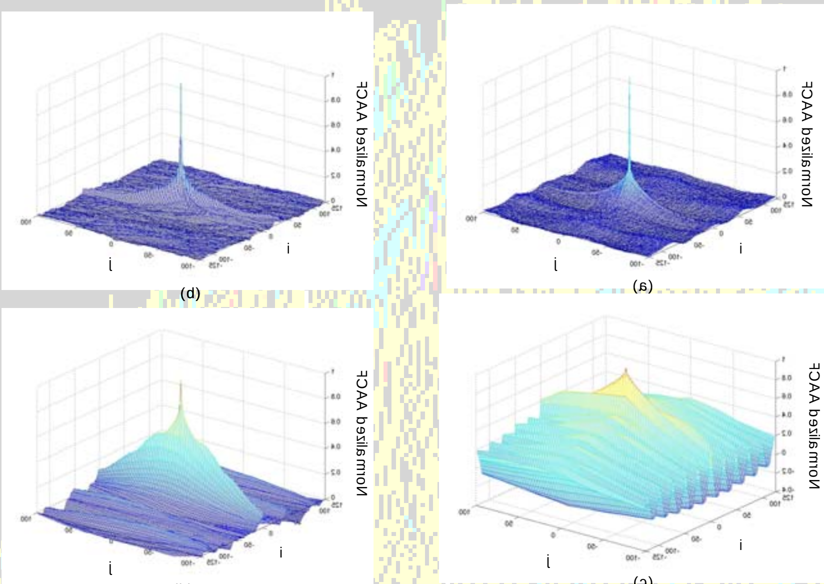
The 3-D surface parameters mentioned earlier were calculated for each surface

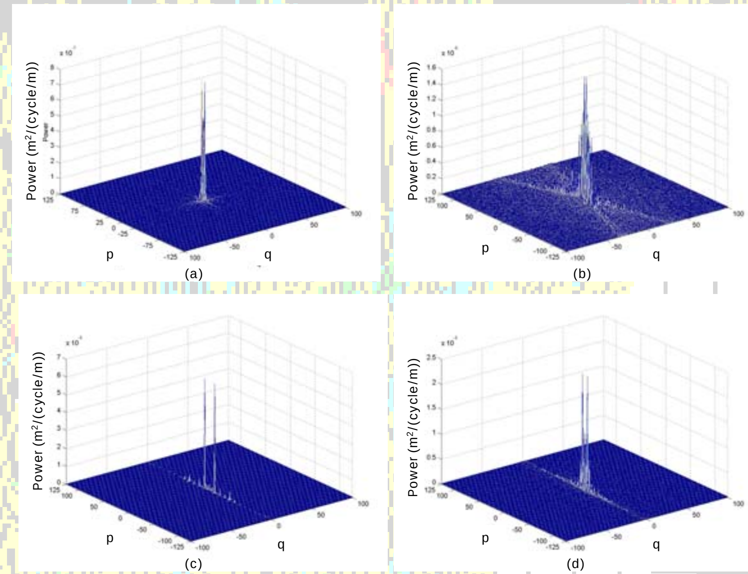
Amplitude Parameters

Mean (St. Dev.)	**IF**	**HN**	**HT**	**GD**
S_q (μm)	**0.066 (0.008)**	**0.26 (0.048)**	**0.32 (0.042)**	**0.52 (0.066)**
S_{sk}	**-1.60 (0.54)**	**-0.06 (0.27)**	**0.29 (0.24)**	**-0.52 (0.23)**

3-D Surface Characterization

To calculate the spatial parameters the AACF, APSD, and Angular spectra for each surface must be analyzed





AACF/APSD plots for (a) IF, (b) HN, (c) HT, and (d) GD

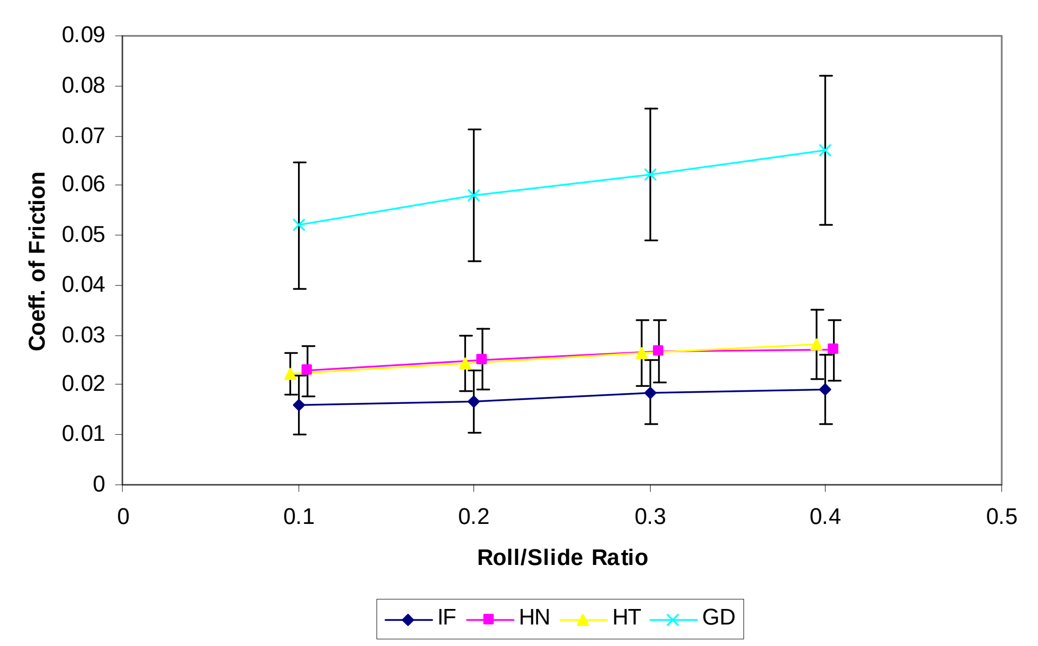
3-D Surface Characterization

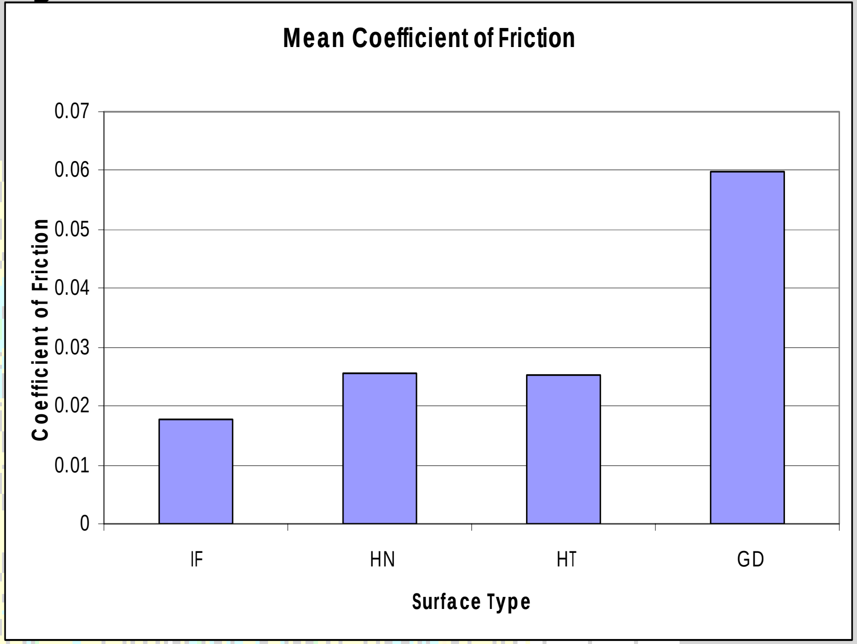
Using AACF, APSD, and Angular spectra, the spatial parameters were calculated

Spatial Parameters

Mean (St. Dev.)	**IF**	**HN**	**HT**	**GD**
S_{al} (μm)	**43.84 (13.03)**	**8.79 (4.83)**	**44.79 (19.86)**	**18.21 (11.95)**
S_{ds} (/mm^2)	**72.97 (10.45)**	**2,129.68 (52.55)**	**92.25 (22.11)**	**636.40 (35.09)**
S_{tr}	**0.68 (0.12)**	**0.27 (0.13)**	**0.19 (0.09)**	**0.10 (0.07)**
S_{td}	**none**	**-75^{o}, 75^{o}**	**90^{o}**	**90^{o}**

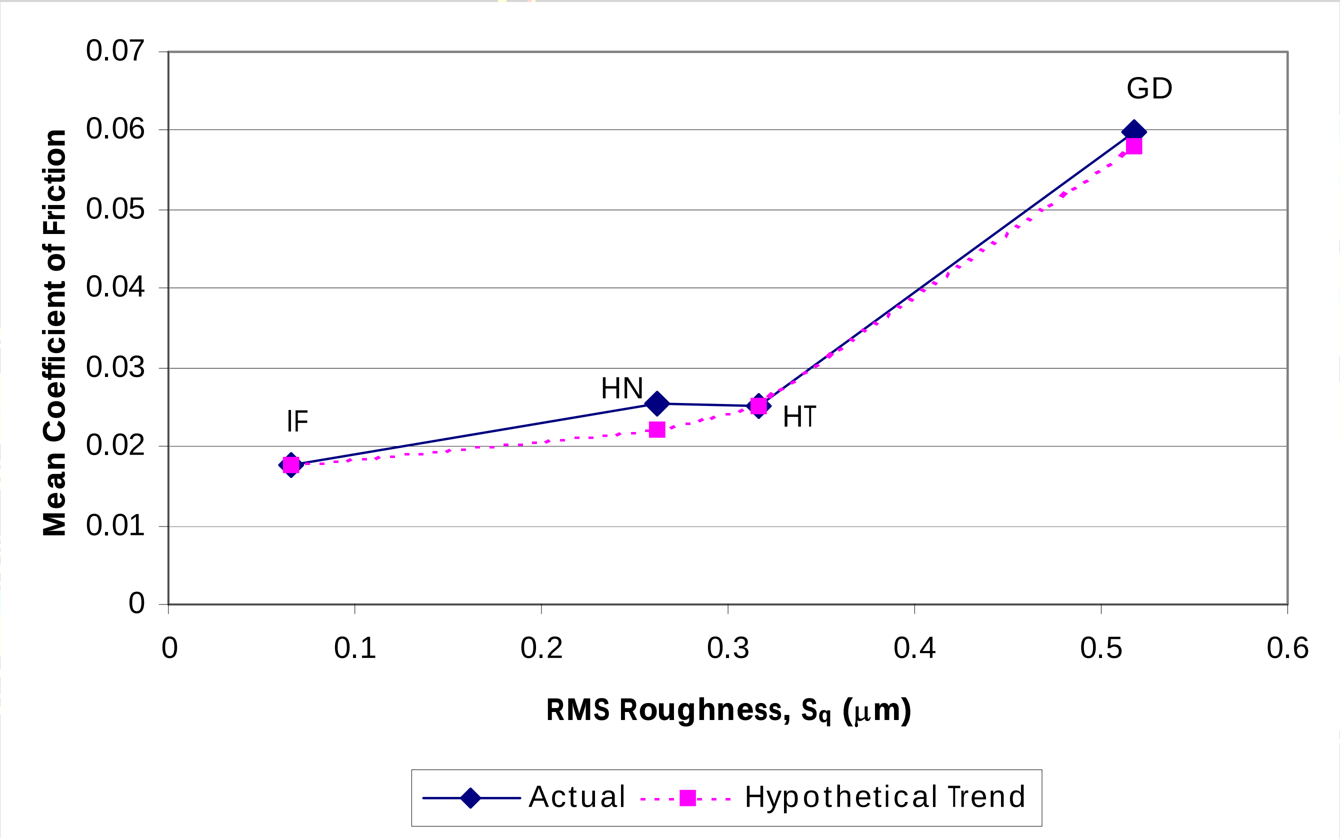
Data Analyses





- GD surface yields highest coefficient of friction
- HT/HN nearly identical
- IF yields lowest coefficient of friction
- Slide-to-roll ratio causes nearly linear increase (slopes differ by surface)

Data Analyses



Hypothetical and Actual Friction Coefficients

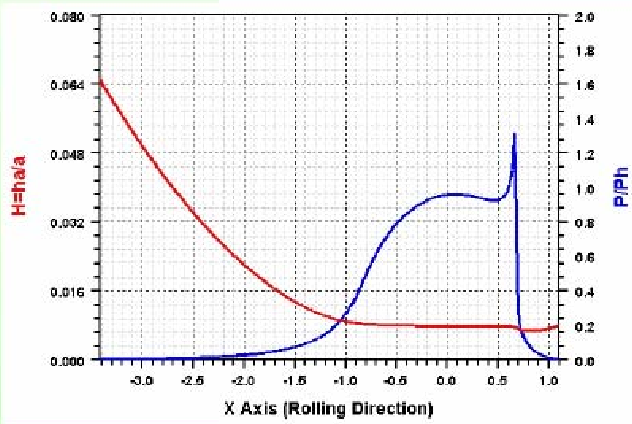
Observations and Conclusions from Rolling/Sliding experiments

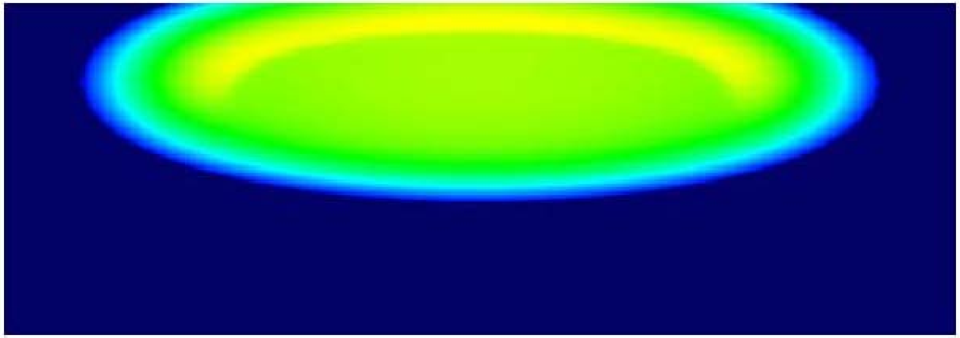
- S_q and S_{ds} can explain the influence of surface texture on the coefficient of rolling/sliding friction

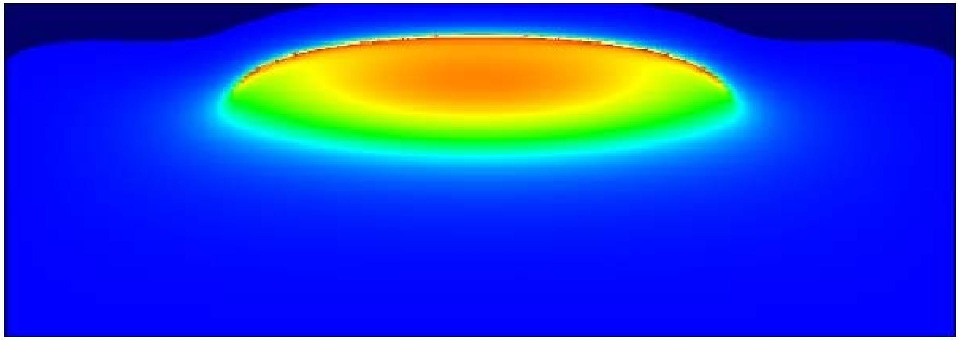
- The coefficient of rolling/sliding friction varies almost linearly with the slide-to-roll ratio

- The similar frictional response for the HN and HT surfaces can be explained by the disparate values of S_q for the two surfaces

A Sample Simulation







Average Film Thickness:
1.7756 μm

Max. Pressure Peak:
$1.3879*P_H$

Film Thickness (λ) Ratio:
infinity

Coef. of Friction:
0.03635

Courtesy: Dr. Dong Zhu
Eaton Corporation

Observations and Conclusions from Simulations

- Unlike the experiments which operated under starved condition the simulations represent flooded condition
- All the conditions operate in full EHL regime thus the effect of surface roughness is masked
- The simulation captures the effect of change in slide to roll ratio.
- The friction predicted is of the same order of magnitude as the experiments

Acknowledgements

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